Commercial Installation of Amine Enhanced Fuel Lean Gas Reburn At Public Service Electric & Gas Mercer Station

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This paper presents nitric oxide (NO_x) reduction results of the first commercial installation of Amine Enhanced Fuel Lean Gas Reburn (AEFLGR). AEFLGR involves the co-injection of 3% to 10% natural gas heat input with amine-containing compounds such as urea via turbulent jets into the upper furnace of fossil fuel boilers while maintaining an overall fuel lean furnace. Maintaining an overall fuel lean furnace environment eliminates the need for downstream completion air and helps prevent excessive carbon monoxide emissions.

Amine Enhanced Fuel Lean Gas Reburn systems were installed on both units at Mercer Station during early 1999. Optimization testing has been completed on Unit 2, and Unit 1 is ready for start-up. Beginning this summer, the station needs deeper NO_x reductions than those obtained with the existing SNCR system. PSE&G's economic analysis showed that AEFLGR could provide very cost-effective NO_x reduction. Both the low capital costs (no completion air addition) and low operating costs (low gas and urea feed rates) made AEFLGR technology attractive to PSE&G.

The Ozone Transport Advisory Group (OTAG) established measures for ozone attainment in the eastern 37 states under Title I of the 1990 CAAA. Since NO_x contributes to tropospheric ozone formation, the reductions required will result in more stringent NO_x emissions limits during the summer "ozone season." Therefore, many utility units that have installed low NO_x burner/overfire air systems or post-combustion control systems will require additional NO_x controls, especially during the summer months. Also, units where low NO_x burners and/or OFA systems are not practical (such as wet bottom and cyclone boilers) need other NO_x control options. AEFLGR has demonstrated cost-effective NO_x reductions on wet bottom and cyclone boilers, and it has demonstrated compatibility with low NO_x burner/overfire air systems.

The AEFLGR process represents a synergistic combination of the Fuel Lean Gas Reburn™ (FLGR) process developed with Gas Research Institute support by ESA and the urea-based NO_xOUT™ process commercialized by Fuel Tech. The chemical kinetic mechanisms of FLGR and SNCR have many of the same selective reactions.

The injection of natural gas in hot, low oxygen furnace gas results in the formation of hydrocarbon radicals (CH_i), and the injection of urea (NH_2-CO-NH_2) results in the formation of amine radicals (NH_i). Both of these radicals reduce NO to molecular nitrogen through a series of very similar selective reactions. The SNCR reactions are highly efficient in reducing NO_x in a narrow temperature window of 1700ºF to 2000ºF. The key to acceptable SNCR process performance is good mixing and reagent dispersion in the flue gas, and injection of the reagents in the proper temperature zone.

Delivering natural gas and the amine reagent to the same reaction zone widens the acceptable reaction temperature window in comparison to the SNCR process, allows amine injection at higher temperatures while limiting amine oxidation to NO, and improves the kinetic rates of the critical chemical reduction mechanisms. The natural gas creates a locally reducing environment for the amine chemistry that raises the acceptable temperature window and prevents the oxidation reactions. Completion of the reactions at higher temperatures also decreases the chances of ammonia "slip", a byproduct of both SNCR and selective catalytic reduction (SCR) processes.

Mercer Generating Station Units 1 and 2 are Foster Wheeler continuous slagging, twin-furnace steam generating units each rated at 324 MW net capacity. The steam generator has a capacity of 2,120,000 pounds per hour of steam with superheater outlet conditions of 2450 psig and 1050ºF and reheater outlet conditions of 445 psig and 1050ºF. Each unit has separate superheat and reheat furnaces. Approximate furnace dimensions are 39 feet wide and 26 feet deep. Each furnace has twelve front wall-mounted burners arranged in three levels with four burners per level. Mercer Units 1 and 2 burn low sulfur, low volatile, eastern bituminous coal as a primary fuel and natural gas as start-up and secondary fuel.

The NO_xOUT™ injectors were located at four elevations (levels 5, 6, 7 and 8) in the existing SNCR systems on Mercer Units 1 and 2. Each level consists of four (4) injectors in line with each burner column. Two gas headers were installed and the injectors at levels 5 and 6 were converted to AEFLGR (urea/gas co-injection capability). The gas headers were properly sized to supply independent natural gas flow, with either level 5 or 6 capable of carrying the entire natural gas flow alone or in any combination. Gas header capability represents roughly 10% of the furnace heat input at full load. Levels 7 and 8 continue as SNCR injectors as part of an integrated system with the AEFLGR injectors at levels 5 and 6. This maintains some NO_x reduction capability without gas use and allows more operational flexibility with the AEFLGR system.

Amine Enhanced Fuel Lean Gas Reburn achieved 55-70% NO_x reductions at Mercer Unit 2 using 7% to 10% natural gas heat input with a urea NSR of 1.0-1.3 overall. Using existing urea costs and a gas-to-coal price differential of $\$1.50/10^6$ Btu, the NO_x removal costs in dollars per ton of NO_x removed are very competitive in comparison to other deep NO_x reduction technologies. NO_x reduction operating costs (from uncontrolled levels) of the commercial AEFLGR system ranged from \$750/ton to \$900/ton for full load operation (310 MW net) through 135 MW net (two mill minimum operation). Because of the low NO_x emission rates at the minimum load of 60 MW net, the NO_x reduction operating costs at minimum load increased to \$1800/ton. However, minimum load is an important operating point for these cycling units, so the AEFLGR system has to operate automatically throughout the boiler load range.

The AEFLGR system operates automatically from 60 MW through full load. Injectors automatically insert and retract as needed based on the optimization testing. Gas and urea flow rates at each level in service follow boiler load, and the furnace excess oxygen level is controlled to the appropriate level based on the quantity of natural gas injected. The units have a tight carbon monoxide (CO) emissions limit of 100 ppm (corrected to 7% excess O_2) at full load, so the gas flow controls have individual furnace CO instrumentation feedback to control gas flow to individual injectors and thereby control CO to 50-60 ppm.

There were no adverse operational impacts from the AEFLGR system throughout the start-up and optimization of the system on Unit 2. Steam temperatures were well controlled with minimal increases in spray flows, there were no problems with slag tapping from the wet bottom furnace, stack opacity was maintained, ammonia "slip" was 5 ppm or less, and CO emissions were controlled below 100 ppm (corrected to 7% excess oxygen).